Monitoring Well Installation Work Plan Addendum 01, Red Hill Bulk Fuel Storage Facility

JOINT BASE PEARL HARBOR-HICKAM, O'AHU, HAWAI'I

January 4, 2017

Comprehensive Long-Term Environmental Action Navy
Contract Number N62742-12-D-1829, CTO 0053

This page intentionally left blank

Monitoring Well Installation Work Plan Addendum 01, Red Hill Bulk Fuel Storage Facility

JOINT BASE PEARL HARBOR-HICKAM, O'AHU, HAWAI'I

January 4, 2017

Prepared for:

Defense Logistics Agency Energy
8725 John J Kingman Rd Suite 4950
Fort Belvoir, VA 22060-6222

Prepared by:

AECOM Technical Services, Inc.
1001 Bishop Street, Suite 1600
Honolulu, HI 96813-3698

Prepared under:

Comprehensive Long-Term Environmental Action Navy
Contract Number N62742-12-D-1829, CTO 0053

This page intentionally left blank

CONTENTS

TABLES

ACRONYMS AND ABBREVIATIONS

%	percent
°C	degree Celsius
AOC	Administrative Order on Consent
APPL	Agriculture & Priority Pollutants Laboratories, Inc.
bgs	below ground surface
CoC	chain of custody
COLIWASA	composite liquid waste sampler
COPC	chemical of potential concern
COR	contracting officer's representative
CTO	contract task order
DLA	Defense Logistics Agency
DoD	Department of Defense, United States
DOH	Department of Health, State of Hawai'i
DON	Department of the Navy, United States
DQI	data quality indicator
ELAP	Environmental Laboratory Accreditation Program
EPA	Environmental Protection Agency, United States
ft	foot or feet
GPS	Global Positioning System
ID	identification
IDW	investigation-derived waste
Investigation WP/SOW	Investigation and Remediation of Releases and Groundwater Protection and Evaluation Work Plan and Scope of Work
JBPHH	Joint Base Pearl Harbor-Hickam
LOQ	limit of quantitation
mL	milliliter
msl	mean sea level
MWIWP	Monitoring Well Installation Work Plan
N/A	not applicable
NAD	North American Datum
NAPL	non-aqueous-phase liquid
NAVFAC	Naval Facilities Engineering Command
Navy	Department of the Navy, United States
OD	outer diameter
OWDF	Oily Waste Disposal Facility
PAH	polynuclear aromatic hydrocarbon
PID	photoionization detector
PVC	polyvinyl chloride
QC	quality control
RPD	relative percent difference
SAP	sampling and analysis plan
SOP	standard operating procedure
SOW	scope of work
TBD	to be determined
TGM	Technical Guidance Manual
TOC	top of casing

TPH	total petroleum hydrocarbons
TPH-d	total petroleum hydrocarbons – diesel range organics
TPH-g	total petroleum hydrocarbons – gasoline range organics
TPH-o	total petroleum hydrocarbons – residual range organics (i.e., TPH-oil)
U.S.	United States
VOA	volatile organic analyte
VOC	volatile organic compound

1. Introduction

This Monitoring Well Installation Work Plan (MWIWP) Addendum documents the proposed approach for installing replacement wells for existing monitoring wells RHMW01 and OWDFMW01 at the Red Hill Bulk Fuel Storage Facility (the "Facility"). The screened intervals of these wells do not bracket the across the water table surface, and consequently may limit assessment of the potential presence of non-aqueous-phase liquid (NAPL) or concentrations of dissolved-phase fuel constituents in groundwater. This MWIWP Addendum intends to serve as a streamlined guide, and supplements information in the MWIWP dated August 29, 2016 (DON 2016b).

This MWIWP Addendum includes the design and rationale of proposed replacement well installation including sampling methods for subsurface unconsolidated material and applicable references. Detailed site background and project quality objectives are provided in the MWIWP and are not covered in this MWIWP Addendum. Additionally, methods and procedures for collecting groundwater samples from the monitoring wells, analyzing the groundwater for the chemicals of potential concern (COPCs), and conducting other investigation activities and analyses are addressed in the project *Work Plan/Scope of Work, Investigation and Remediation of Releases and Groundwater Protection and Evaluation, Red Hill Bulk Fuel Storage Facility* (the "Investigation WP/SOW") (DON 2016c), and the forthcoming project *Sampling and Analysis Plan* (SAP).

The activities proposed under this MWIWP Addendum 01, the MWIWP (DON 2016b), and the Investigation WP/SOW (DON 2016c) are part of an investigation being performed by the United States (U.S.) Department of the Navy (DON; "Navy") and Defense Logistics Agency (DLA) in order to address the requirements and achieve the objectives of the Administrative Order on Consent (AOC) issued by the U.S. Environmental Protection Agency (EPA) Region 9 and the State of Hawai'i Department of Health (DOH) (EPA Region 9 and DOH 2015). The investigation specifically addresses the AOC Statement of Work Section 6, Investigation and Remediation of Releases, and Section 7, Groundwater Protection and Evaluation. The monitoring well installation activities proposed under this MWIWP Addendum will be conducted as part of Task 4 *Expand the Monitoring Well Network* presented in the Investigation WP/SOW (DON 2016c, Section 3.4).

2. Replacement Well Rationale and Design

This section describes the rationale to install two replacement monitoring wells (RHMW01R and OWDFMW01R) for existing wells RHMW01 and OWDFMW01 and the design for each well, including drilling, unconsolidated material sampling, rock coring, well installation, and development. The design and rationale for subsequent groundwater sampling and analysis are described in the Investigation WP/SOW (DON 2016c) and the forthcoming project SAP.

2.1 Rationale for Replacement Monitoring Well Installation

Monitoring wells RHMW01 and OWDFMW01 are included in the existing Red Hill groundwater monitoring well network (Figure 1). Well RHMW01 is located inside the Facility's lower-access tunnel near Tank 1, and well OWDFMW01 is located at the former Oily Waste Disposal Facility (OWDF). Although these monitoring wells comprise important sentinel locations, water table elevations are found to be consistently above the top of well screens in both wells (see Appendix A for well construction logs [DON 2000, 2002]). As shown in Table 2-1, groundwater levels have been measured approximately 5 feet (ft) and 13 ft above the top of screen in wells RHMW01 and OWDFMW01, respectively.

Table 2-1: Well Construction Details

Well ID	Ground Surface (ft msl)	Top of Casing (ft msl)	Casing Diameter and Type	Estimated Depth to Bedrock (ft)	Ground-water Surface (ft msl) [a]	Well Screen Interval (ft msl)	Top of Filter Pack (ft msl)	Borehole Bottom Depth (ft bgs)	Borehole Bottom Elevation (ft msl)
Existing Wells									
RHMW01	102.51	102.41 [b]	1" SCH 80	N/A	19.54	12.61 to 2.61	15.66	100	2.51
OWDFMW01	136.18	138.57 [b]	4" SCH 80	49	17.97	4.16 to -5.84	16.74	143	-4.06
Proposed Replacement Wells									
RHMW01R	103	TBD	4" SCH 80 [c]	N/A	19.54	28 to -2	33	106	-3
OWDFMW01R	139	TBD	4" SCH 80	49	17.97	28 to -2	33	142	-3

bgs below ground surface (for RHMW01, below the tunnel floor)
msl mean sea level
N/A not applicable
PVC polyvinyl chloride
SCH Schedule
TBD to be determined

[a] Source: Department of the Navy. 2016. Final Third Quarter 2016 - Quarterly Groundwater Monitoring Reports for Inside Tunnel and Outside Tunnel Wells. Prepared by Element Environmental, LLC for Naval Supply Systems Command (October).

[b] Source: DON 2007.

[c] 1-inch Schedule 80 PVC maybe installed if installation through 4-inch Schedule 80 PVC conductor casing is required, as noted in Section 3.3.1.2.

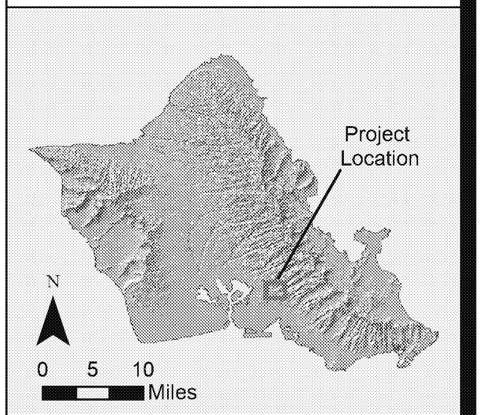
If the water table surface occurs above the saturated portion of screen, then unrepresentative assessments may be made of the potential presence of NAPL or concentrations of dissolved-phase fuel constituents in groundwater at these locations.

Prior to drilling RHMW01R, a downhole video survey will be conducted to confirm that the entire RHMW01 well screen is in fact saturated since well records indicate that the water table is approximately 5 ft above the top of the slotted screen interval. If the downhole video confirms that the water table is actually below the slotted screen interval, then replacement of RHMW01 will not be required. Since well installation records indicate that the difference between the groundwater surface and the slotted screen interval at OWDFMW01 is significantly greater and it is highly unlikely that the slotted screen interval could intersect the groundwater surface, video confirmation of OWDFMW01 will not be conducted.

If the entire screened interval at RHMW01 is saturated and is confirmed based on the video survey, or if the survey is inconclusive, then both replacement wells (RHMW01R and OWDFMW01R) will be installed. Replacement wells will be constructed with screened intervals fully spanning the anticipated seasonal range of groundwater surface elevations. Based on groundwater elevation data collected during quarterly groundwater monitoring, the maximum fluctuation was 2.45 ft at RHMW01 since 2007 and 1.71 ft at OWDFMW01 since 2011. Consequently, more representative data will be obtained from the replacement wells to achieve the objectives summarized in Table 2-2.

S:\Projects\NAVFAC PAC\CLEAN IV\60481\2456CTO 00539\00-Work\920 GIS\02_Maps\MW_WP Add01\Fig1_SiteLocMap_MWWP.mxd 1/3/2017

Location Map



Legend

- Proposed Reinstallation Monitoring Well Location
- Existing Monitoring Well Location
- Existing Water Supply Well
- Red Hill Tank
- Stream
- 400 Topographic Contour (feet above mean sea level)
- Red Hill Installation Boundary

Notes

1. Map projection: NAD 1983 UTM Zone 4N
2. Base Map: DigitalGlobe, Inc. (DG) and NRCS. Publication_Date: 2015

N

0 400 800 1,600 Feet

Figure 1
Site Location Map
Monitoring Well Installation
Work Plan Addendum 01
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, Hawai'i

This page intentionally left blank

Table 2-2: Proposed Well and Objectives Matrix

Well ID	Objective 1: Sentinels	Objective 2: Characterize Flow	Objective 3: Characterize Chemistry	Objective 4: Characterize Matrix	Objective 5: Other Uses
RHMW01R	✓	✓	✓		✓
OWDFMW01R	✓	✓	✓	✓	✓

ID identification

Objectives:

1. *Sentinels* – Provide monitoring points between the Red Hill tanks or areas within the Facility boundaries where COPCs have been detected in groundwater and receptors potentially exposed via the drinking water supply system.
2. *Characterize Flow* – Provide additional groundwater elevation data to evaluate groundwater flow patterns in the vicinity of the Red Hill Facility and refine and calibrate the groundwater flow model.
3. *Characterize Groundwater Chemistry* – Provide water quality data and evaluate presence or absence of NAPL, COPC concentrations and natural attenuation parameters.
4. *Characterize Matrix* – Further characterize the stratigraphy and properties of the valley fill, caprock, and saprolite layers.
5. *Other Uses* – Provide potential monitoring and access points for other activities, such as a tracer study or augmentation, if warranted upon completion of other field activities.

2.2 PROPOSED REPLACEMENT WELL DESIGN AND INSTALLATION PROCEDURES

Several drilling technologies will be required to install the replacement wells. Proposed drilling technologies include hollow-stem auger, wet rotary coring, and air rotary drilling. Based on accessibility to the locations and existing borehole logs for RHMW01 and OWDFMW01 (Appendix A), the types of equipment used and subsurface conditions at each location will be different. Sections 2.2.1 and 2.2.2 describe the design and installation methods anticipated for the installation of RHMW01R and OWDFMW01R, respectively. Details regarding the procedures to be followed during the installation of the replacement wells are presented in Section 3.

Due to the heterogeneous nature of the subsurface geology at the site, samples of unconsolidated material and continuous core samples of the basalt bedrock will be collected to further characterize subsurface conditions. If subsurface conditions or site characteristics differ from what is currently understood, then alternative drilling approaches may be required.

Subsurface geotechnical samples of unconsolidated material will be collected if zones of unconsolidated material or significant layers of clay or low-permeability zones are encountered in the vadose zone. Additionally, if unconsolidated material is present at depths below the bottom of the tanks (120 ft above mean sea level [msl]), or if any contaminated unconsolidated material is observed in the vadose zone, then samples of subsurface unconsolidated material will be collected for laboratory analysis of COPCs to provide additional data on the level of contamination present in the area. Like the rock cores, the subsurface unconsolidated material samples will be inspected for evidence of contamination (visual, olfactory, or elevated photoionization detector [PID] readings) in order to characterize the lithology and evaluate the potential migration of NAPL and associated constituents.

If perched water or evidence of contamination (i.e., visual, olfactory, or elevated PID readings) is observed during drilling, then coring will be stopped after drilling past the perched water zone or contaminated interval so that permanent conductor casing can be installed.

Although the DOH *Technical Guidance Manual for the Implementation of the Hawaii State Contingency Plan* (TGM) (DOH 2016) generally recommends 10-ft well screens, previous investigators have reported difficulties in accurately determining the groundwater depth during drilling (prior to setting the wells), which likely resulted in existing wells RHMW01 and

OWDFMW01 being screened at elevations below the current groundwater surface elevation. Therefore, 30-ft screens are recommended for the replacement wells to:

- Accommodate potentially large variations in water levels due both to natural forces (such as seasonal variations and drought conditions) and induced forces (such as variable supply well pumping rates that can impose variable drawdown conditions).
- Ensure that NAPL, if present, can accumulate within the well under these variable conditions.
- Maintain consistency with other recently installed site monitoring wells (i.e., to sample from comparable intervals).

The wells will be installed with approximately 20 ft of slotted screen below and 10 ft of slotted screen above the water table surface; however, there may be additional variation required at OWDFMW01 if the boring yields no apparent groundwater or volumes determined to be insufficient for sampling within 20 ft below the groundwater surface.

After completion, the measuring point of each well will be surveyed using first order survey techniques, as described in the Investigation WP/SOW (DON 2016c) and the forthcoming project SAP.

2.2.1 RHMW01R Design and Installation Procedures

RHWM01R will be drilled in the vicinity (10–20 ft) of RHMW01, which is located inside the lower-access tunnel.

Accessing the RHMW01R drilling location will require the use of a specialized compact electrically operated (45 kW, 380V) diamond core drill designed to operate underground or similar drill rig to accommodate the lower-access tunnel train transport requirements and limited overhead conditions. This drill rig will initially be used to core through solid basalt rock, anticipated to be directly below the tunnel concrete floor, using wet rotary drilling methods. Coring will be conducted to approximately 106 ft beneath the tunnel floor surface.

If perched water or evidence of contamination is observed, then coring will be discontinued and conductor casing will be installed to seal off the zone of perched water or contamination. The conductor casing will be permanently grouted in place. After installation of the conductor casing, continuous coring will resume through the conductor casing to approximately 106 ft beneath the tunnel floor.

After rock coring is complete, the borehole will be reamed to a larger diameter for well installation using rotary drilling techniques. Well installation will include either a 4-inch-diameter polyvinyl chloride (PVC) well if no conductor casing is installed, or a 1-inch-diameter PVC well if it is installed through 4-inch-diameter PVC conductor casing. The well will be completed with slotted PVC screen. Coarse silica sand filter pack will be placed around the screen interval, and the well will be sealed with a bentonite pellet seal followed by bentonite slurry and cement-bentonite grout. The well will be completed as flush mount due to the limited access area within the tunnel to avoid potential interference with Facility operations. Figure 2 shows the general proposed well construction details for RHMW01R.

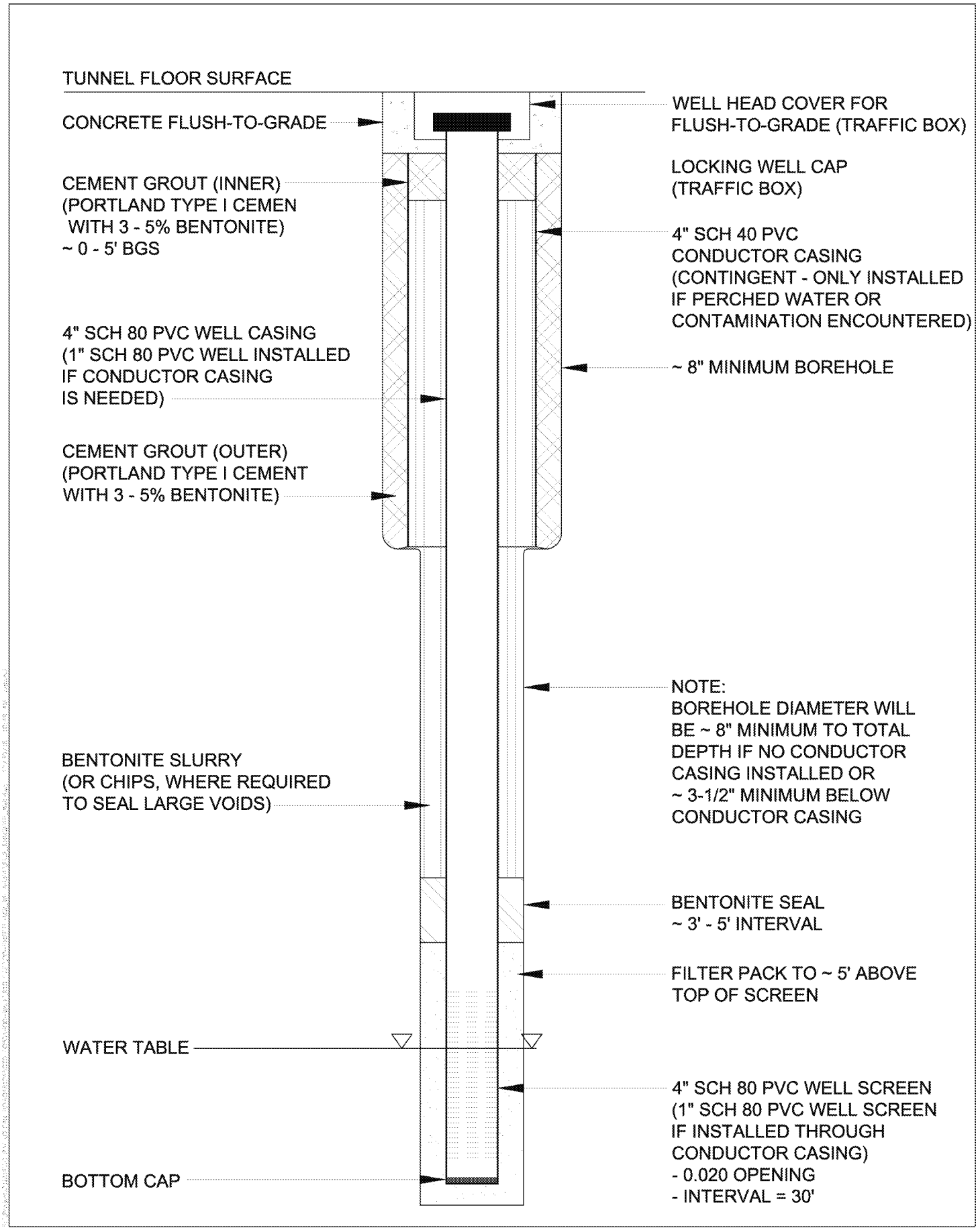


Figure 2
Cross Section of RHMW01R Monitoring Well
Monitoring Well Installation Work Plan Addendum 01
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, Hawai'i

This page intentionally left blank

2.2.2 OWDFMW01R Design and Installation Procedures

During previous drilling activities at the OWDF, perched groundwater conditions were encountered and are associated with the presence of low-permeability volcanic tuff and unconsolidated layers (silt and clay). The occurrence of these low-permeability layers are localized, and they were not observed at all drilling locations across the site (DON 2000). During the installation of well OWDFMW01 (previously referred to as MW08), perched groundwater conditions were not observed; however, a low-permeability basalt interval was encountered at the depth where the water table was expected to occur (115 ft below ground surface [bgs]). Drilling continued to 138.5 ft bgs before groundwater was observed, and the groundwater level subsequently stabilized at approximately 122 ft bgs (DON 2000). It is proposed that OWDFMW01R be installed within 20 ft of OWDFMW01 to maintain consistency with the location where groundwater samples have been collected during previous sampling events. Figure 3 shows the general proposed well installation details for OWDFMW01R.

Based on existing information, it is anticipated that up to approximately 50 ft of unconsolidated material and layers of basalt or basalt boulders will be encountered at OWDFMW01R. If boulders or layers of basalt are encountered that result in hollow-stem auger refusal, then drilling techniques may be switched between hollow-stem auger and downhole hammer air rotary methods until competent bedrock is encountered. The borehole will be drilled to refusal or solid basalt bedrock using hollow-stem augers for the collection of soil samples for lithological characterization and chemical analyses if unconsolidated material is encountered below 100 ft msl or observed to be contaminated (i.e., visual, olfactory, or elevated PID readings).

If perched water or evidence of contamination (i.e., visual, olfactory, or elevated sustained PID readings above ambient background conditions) is observed during drilling (i.e., hollow-stem auger, air rotary, coring), then drilling will be stopped so that permanent conductor casing can be installed to seal off the perched water or contaminated interval. The conductor casing will be permanently grouted in place.

Solid basalt bedrock will be continuously cored using wet rotary drilling techniques. After rock coring is complete, the borehole will be reamed to a larger diameter using air rotary drilling techniques for well installation. The well will be installed as a 4-inch-diameter PVC well and completed with 30 ft of slotted PVC screen placed across the groundwater surface. A coarse silica sand filter pack will be placed around the slotted screen interval, and the well will be sealed with a bentonite pellet seal, bentonite slurry and cement-bentonite grout. The well will be completed as an aboveground well with a protective steel cover.

3. Field Project Implementation

3.1 Project Procedures

All drilling, monitoring well installation, and other field activities will be conducted in accordance with the DOH TGM (DOH 2016) and the standard operating procedures (SOPs) summarized in Table 3-1, which are from the *Project Procedures Manual, U.S. Navy Environmental Restoration Program, Naval Facilities Engineering Command* [NAVFAC], *Pacific* (DON 2015). These SOPs are presented in Appendix A of the MWIWP (DON 2016b). Additionally, Appendix B of the MWIWP presents the project organizational chart and communication pathways that will be maintained in order to ensure proper oversight and communication throughout all planned field activities. A Health and Safety Plan has been prepared under separate cover to address potential health and safety concerns that may arise during field work (DON 2016a).

Table 3-1: Field SOPs Reference Table

Reference Number	Title, Revision Date and/or Number [a]	Originating Organization of Sampling SOP	Equipment Type
I-A-5	*Utility Clearance*	NAVFAC Pacific	Geophysical equipment (electromagnetic, magnetic, and ground-penetrating radar)
I-A-6	*Investigation Derived Waste Management*	NAVFAC Pacific	N/A
I-A-8	*Sample Naming*	NAVFAC Pacific	N/A
I-B-1	*Soil Sampling*	NAVFAC Pacific	Split-spoon sampler and liners with hollow-stem or solid-stem auger
I-B-2	*Geophysical Testing*	NAVFAC Pacific	Low frequency electromagnetic induction, magnetometers, and ground-penetrating radar
I-C-1	*Monitoring Well Installation and Abandonment*	NAVFAC Pacific	Continuous coring drill rig
I-C-2	*Monitoring Well Development*	NAVFAC Pacific	Surge block or submersible pump
I-D-1	*Drum Sampling*	NAVFAC Pacific	COLIWASA or glass thieving tubes
I-E	*Soil and Rock Classification*	NAVFAC Pacific	N/A
I-F	*Equipment Decontamination*	NAVFAC Pacific	N/A
I-I	*Land Surveying*	NAVFAC Pacific	Theodolite - horizontal and vertical control; GPS
III-A	*Laboratory QC Samples (Water, Soil)*	NAVFAC Pacific	N/A
III-B	*Field QC Samples (Water, Soil)*	NAVFAC Pacific	N/A
III-D	*Logbooks*	NAVFAC Pacific	N/A
III-E	*Record Keeping, Sample Labeling, and Chain of Custody*	NAVFAC Pacific	N/A
III-F	*Sample Handling, Storage and Shipping*	NAVFAC Pacific	N/A

COLIWASA composite liquid waste sampler
GPS Global Positioning System
N/A not applicable
QC quality control
[a] Applicable procedures from the *Project Procedures Manual* (DON 2015).

3.2 SITE SURVEYS AND PREPARATION

3.2.1 Video Inspection of Existing Well RHMW01

Well RHMW01 is constructed as a 1-inch-diameter PVC well, and the groundwater surface at this location is presumed to be approximately 5 ft above the slotted portion of screen, based on available well records. The objective of videoing RHMW01 is to visually confirm the location of the slotted screen relative to the groundwater surface. A downhole camera will be deployed in the well to visually record and document the groundwater surface and well construction. The video recorder will log the depth as the inside of the well is photographed, and the camera will be run to the bottom of the well to document the total depth of the well and ensure the depths recorded are accurate. The video will be downloaded on mp4 or similar file format so that it can be viewed on computer after filming is complete.

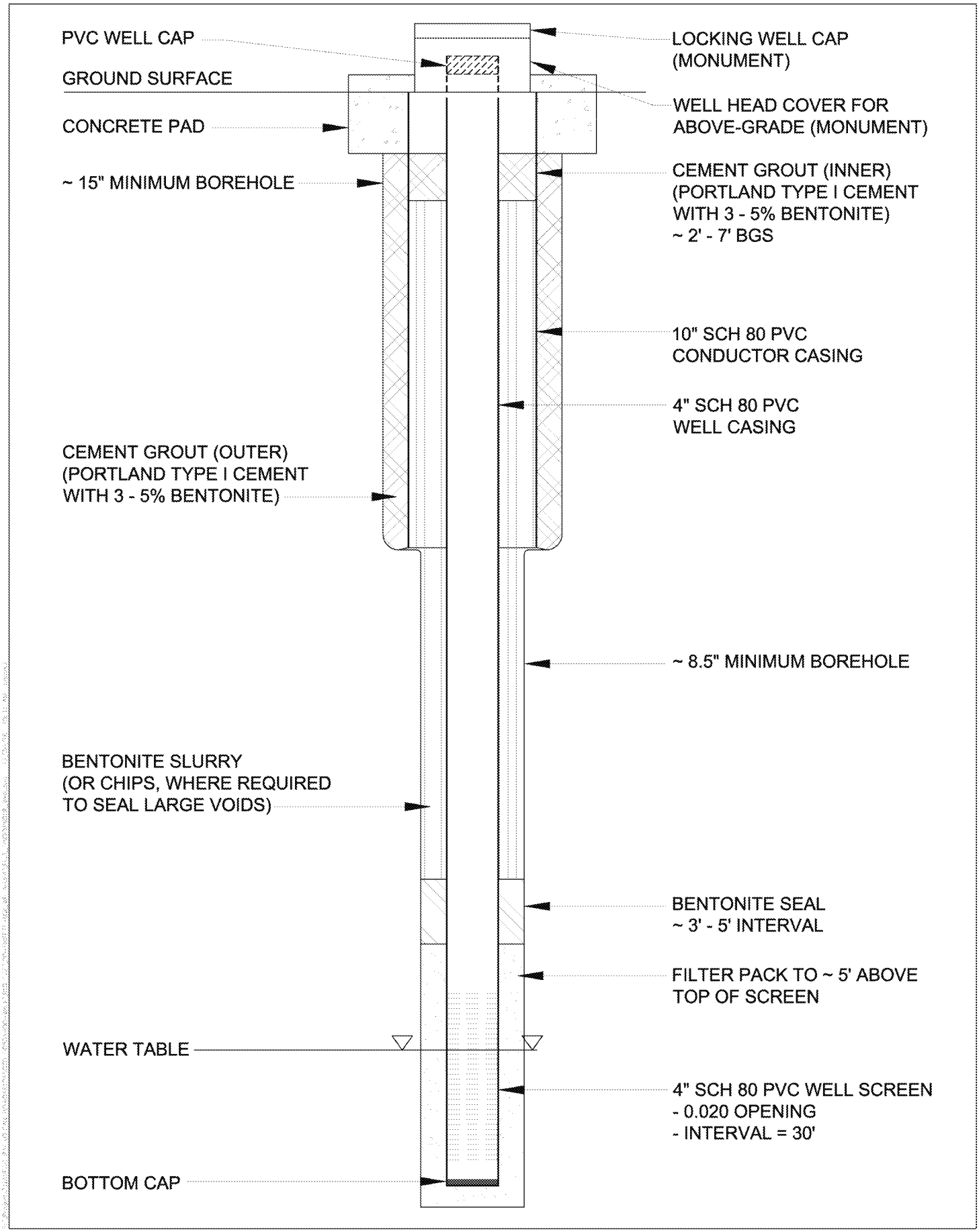


Figure 3
Cross Section of OWDFMW01R Monitoring Well
Monitoring Well Installation Work Plan Addendum 01
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, Hawai'i

This page intentionally left blank

3.2.2 Site Preparation

Existing monitoring wells RHMW01 and OWDFMW01 will be located by the field team, and proposed monitoring well reinstallation locations will be marked with white paint and/or wooden stakes. The replacement wells will be placed approximately 20 ft away from RHMW01 and OWDFMW01; however, if the locations need to be adjusted due to unanticipated conditions, they will be located no closer than 10 ft to the existing monitoring wells to avoid interferences during installation. Site preparation will include cutting or coring of concrete, as required to facilitate drilling and well completion. Each borehole location will be marked once the area is cleared and the staging area is established.

3.2.3 Utility Clearance

Utility clearance procedures are presented in the MWIWP (DON 2016b).

3.2.4 Drill Rig Access

Proposed monitoring well RHMW01R will require drill rig and associated equipment/materials access via the lower-access tunnel train system. Proposed monitoring well OWDFMW01R is located outside of the tunnels and will be accessed by a standard truck-mounted drill rig.

3.3 Drilling and Well Installation

Solid basalt bedrock is anticipated to be encountered at shallow depths at proposed well locations RHMW01R and OWDFMW01R (i.e., directly below surface and 50 ft bgs, respectively). Anticipated drilling activities include:

- Hollow-stem auger drilling through soil overburden at OWDFMW01R
- Rock coring using wet rotary wireline methods at RHMW01R and OWDFMW01R
- Air rotary drilling to increase borehole diameter for well installation at RHMW01R and OWDFMW01R

All onsite activities must be coordinated with the Navy contract task order (CTO) contracting officer's representative (COR) to ensure that all requirements such as obtaining site access, working hours, use/accessing potable water supply sources, and other requirements are understood and followed. Prior to any drilling, a hand auger or other hand tool will be used if there is overburden present at the drilling location to manually advance the borehole to 5 ft bgs to ensure the location is cleared of utilities.

The drill rig will be leveled at least twice a day to prevent potential borehole deviation. In addition, the well borings will initially be cored, which will help ensure that the initial borings are straight. After coring, the borehole will be reamed to a larger diameter, during which a pilot bit will be used below the primary bit to ensure that the boring follows and is centered over the core hole. After the well construction is completed, a quantitative true vertical depth analysis using a gyroscopic alignment instrument will be performed so appropriate corrections can be made to wireline-measured depth to water. The gyroscopic alignment will be conducted on all wells within the Red Hill groundwater monitoring program; details regarding the procedures to be followed will be presented in the forthcoming project SAP (see DON 2016c).

Perched water or evidence of contamination (i.e., visual, olfactory, or elevated PID readings) may be encountered in the vadose zone. To facilitate identification of perched groundwater or subsurface contamination, the borehole will be checked for standing water using an interface probe at least four

times a day during drilling. Measurements will be made at least at the beginning and end of each shift (i.e., twice before and twice after lunch), but also more frequently based on the presence of features that may suggest perched water (e.g., porous zones [e.g., saturated soil cuttings, sand, gravel, or clinker zones] overlying lower permeability zones [i.e., silt, clay, low-porosity basalt layer]) based on visual observation. A bailer and an oil/water interface probe will also be used to check for the presence of a sheen or NAPL at the same frequency as water level measurements are made. Additionally, the presence of contamination may be indicated by staining on drill cuttings and recovered rock cores and by sustained PID readings above ambient background conditions. This information will be recorded in the project field book.

Sounding tubes are not proposed for installation at either replacement well location. Well diameters have been selected that will allow the installation of equipment for well gauging and sampling. However, if conductor casing is required for RHMW01R, then a smaller-diameter well will be installed that may require dedicated sampling equipment be removed to allow for well gauging or other activities. Details regarding the installation of replacement wells RHMW01R and OWDFMW01R are presented in Sections 3.3.1 and 3.3.2, respectively.

3.3.1 RHMW01R Drilling and Well Installation Procedures

3.3.1.1 RHMW01R Drilling

Drilling will be conducted in accordance with Procedure I-C-1, *Monitoring Well Installation and Abandonment* (DON 2015). Drilling at RHMW01R will be conducted using an electrically operated drill rig equipped with rock coring and wet rotary drilling capabilities. Solid basalt bedrock is anticipated to be encountered directly below the lower-access tunnel floor. Coring will be conducted once competent bedrock is encountered as described in Section 3.3.3.

Checks for perched water or evidence of contamination will be made as described in the introductory portion of Section 3.3. If perched water or evidence of contamination is observed, then 4-inch-diameter Schedule 40 PVC conductor casing will be installed as described in Section 3.3.4. If perched water or evidence of contamination is not observed, coring will be conducted until the target depth (approximately 106 ft bgs) is reached. After rock coring is complete, the borehole will be reamed to total depth with a conventional, rotary drilling rig to increase the borehole diameter to a minimum of 8 inches (Figure 2). Clean, potable water (and environmentally safe drilling foam, only if pre-approved by the Navy) and bentonite drilling mud will be injected as needed during drilling to mitigate dust, lubricate downhole tools, stabilize the borehole and remove cuttings from the borehole. Attempts will be made to limit fluids injected during drilling, but the amount of fluid used will be dependent on the porosity of the formation being drilled. Prior to use, potable water for drilling will be sampled and analyzed for COPCs as described in the MWIWP (DON 2016b) and Section 4 of this Addendum). Cuttings removed from the boreholes will be collected in 55-gallon drums. Use of wet rotary drilling methods and injection of water during drilling will significantly reduce the generation of dust during drilling.

3.3.1.2 RHMW01R Monitoring Well Installation

After the borehole has been reamed with the air rotary drilling equipment, the monitoring well will be installed in accordance with Procedures I-C-1, *Monitoring Well Installation and Abandonment* and I-C-2 *Monitoring Well Development* (DON 2015). Groundwater in the basal aquifer is expected to be encountered at approximately 15–20 ft msl. Within the borehole, 4-inch-diameter, Schedule 80 PVC-casing with 30 ft of 0.02-inch slotted screen will be constructed (Figure 2). However, if a 4-inch-diameter Schedule 40 PVC conductor casing is required, then a 1-inch-diameter Schedule 80 PVC monitoring well will be installed inside the conductor casing. The well will be screened within

the basal aquifer approximately 10 ft above and 20 ft below the groundwater surface. The estimated total depth for RHMW01R is approximately 106 ft below the tunnel floor.

To ensure that the well casing is centered in the borehole, centralizers will be installed at the top and bottom of screened sections and also placed at 40-ft intervals on blank well casing. The centralizers will be aligned from top to bottom of the casing so that they do not interfere with the insertion and removal of the tremie pipe. All devices used to affix centralizers to the casing will not puncture the casing or contaminate the groundwater with which they come in contact. Centralizers will be constructed of stainless steel. To ensure even distribution of filter pack, bentonite seal, and grout materials around the well within the borehole, the well casing and screen will be suspended with a threaded hoisting plug and not allowed to rest on the bottom of the borehole.

Coarse #3 Monterey silica sand will be emplaced via tremie pipe into the borehole annulus to approximately 5 ft above the slotted well screen, followed by a 3- to 5-ft thick bentonite pellet seal, then wet bentonite grout slurry (e.g., Wyo-Ben Enviroplug Grout) to within 5 ft of the ground surface. If large voids are encountered, then bentonite chips may be required to seal the voids. The proposed well construction details for RHMW01R are shown on Figure 2. The bentonite slurry (or chips, where required) will be slowly emplaced via tremie pipe to ensure proper filling of the annulus and to avoid bridging. The slurry will be placed to within approximately 7 ft of the tunnel floor. Dry bentonite chips, where used, will be tremied and hydrated with clean, potable water using at least 5 gallons of water per 50-pound bag of chips. The remaining annular space from approximately 7 to 2 ft bgs will be finished by grouting with cement bentonite grout. Well construction diagrams will be provided on the geologic logs.

Because the rock formation is not pressured, blowouts are not anticipated to occur. However, as described above, voids are anticipated to be encountered and need to be taken into consideration during well installation. In the event that voids or blowouts are encountered, bentonite chips will be emplaced down hole to close out or plug the void.

3.3.1.3 RHMW01R Monitoring Well Surface Completion

The monitoring well will be completed in accordance with Procedure I-C-1, *Monitoring Well Installation and Abandonment*. Monitoring well RHMW01R will be completed flush-mount to avoid obstructing any portion of the lower-access tunnel. The flush-mount surface completion will consist of a 12-inch-diameter, circular steel skirt or rectangular utility-type box with a gasket to prevent leaks and traffic-rated locking lid over the recessed well. The circular skirt or box would be set in concrete flush with the grade surface of the tunnel to provide strength and a watertight surface seal.

3.3.2 OWDFMW01R Drilling and Well Installation Procedures

3.3.2.1 OWDFMW01R Drilling

The drilling approach for monitoring well OWDFMW01R will be consistent with the methodologies presented in the MWIWP (DON 2016b), including the use of hollow-stem auger drilling to advance through overburden (estimated to be up to approximately 50 ft thick) and down-hole hammer air rotary methods within the underlying rock. However, drilling techniques may be switched between hollow-stem auger and downhole hammer air rotary methods if alternating sequences of soil and rock are encountered.

OWDFMW01R will be drilled using a truck-mounted drill rig equipped with hollow-stem augering, rock coring, and air rotary capabilities in accordance with Procedure I-C-1, *Monitoring Well Installation and Abandonment* (DON 2015). The borehole will initially be advanced to refusal using

a minimum 4¼-inch-inner-diameter hollow-stem augers that can be used as a temporary surface casing during rock coring activities. Characterization samples of unconsolidated material will be collected at 5-ft intervals beginning at 10 ft bgs with 1.5-ft-long, 2-inch-diameter split spoons. A split-spoon will be used to collect unconsolidated material samples after retracting the hammer and running the sampler in the open hole. It is possible that basalt cobbles and boulders will be encountered, making recovery difficult for characterization sampling of unconsolidated material (i.e., poor recovery) or resulting in refusal, in which case an air hammer may be used to advance the borehole.

Checks for perched water or evidence of contamination will be made as described in the introductory portion of Section 3.3. If perched water or evidence of contamination is observed, then conductor casing will be installed as described in Section 3.3.4.

Coring will be conducted until the target depth (147 ft bgs) is reached; however, coring may extend beyond the target depth until a fractured or porous interval that yields sufficient quantities of water for the collection of a groundwater sample. After rock coring is complete, the borehole will be reamed to total depth with a conventional, open-hole air rotary drilling rig to increase the borehole diameter to a minimum of 8.5 inches (Figure 3). Clean, potable water (and environmentally safe drilling foam, only if pre-approved by the Navy) and bentonite drilling mud will be injected during drilling to mitigate dust, lubricate downhole tools, stabilize the borehole and remove cuttings from the borehole. Attempts will be made to limit fluids injected during drilling, but the amount of fluid used will be dependent on the porosity of the formation being drilled. Prior to use, potable water for drilling will be sampled and analyzed for COPCs as described in the MWIWP (as noted in Section 3.3.8 of this Addendum). Cuttings removed from the boreholes will be collected in 55-gallon drums or a rolloff container equipped with air stacks to reduce dust.

3.3.2.2 OWDFMW01R Monitoring Well Installation

After the borehole has been reamed with the air rotary drilling equipment, the monitoring well will be installed in accordance with Procedure I-C-1, *Monitoring Well Installation and Abandonment.* Based on the installation history of the original OWDFMW01, care will be taken to allow the water level in the borehole the time to stabilize before installation. Groundwater in the basal aquifer is expected to be encountered at approximately 15–20 ft msl. Within the borehole, a 4-inch-diameter, Schedule 80 PVC-cased monitoring well with 30 ft of 0.02-inch slotted screens will be constructed (Figure 3). The well will be screened within the basal aquifer approximately 5-10 ft above and 20-25 ft below the groundwater surface. The estimated total depth OWDFMW01R is 147 ft bgs; however, the depth may be extended if groundwater is not encountered within 5 ft of the proposed target depth.

To ensure that the 4-inch-diameter well casing is centered in the borehole, centralizers will be installed at the top and bottom of screened sections and also placed at 40-ft intervals on blank well casing. The centralizers will be aligned from top to bottom of the casing so that they do not interfere with the insertion and removal of the tremie pipe. All devices used to affix centralizers to the casing will not puncture the casing or contaminate the groundwater with which they come in contact. Centralizers will be constructed of stainless steel. To ensure even distribution of filter pack, bentonite seal, and grout materials around the well within the borehole, the 4-inch-diameter well casing and screen will be suspended with a threaded hoisting plug and not allowed to rest on the bottom of the borehole. Coarse #3 Monterey silica sand will be emplaced via tremie pipe into the borehole annulus to approximately 5 ft above the well screen, followed by a 3- to 5-ft thick bentonite pellet seal, then wet bentonite grout slurry (i.e., Wyo-Ben Enviroplug Grout) to within approximately 7 ft of the ground surface. If large voids are encountered, then bentonite chips may be required to

seal the voids. The proposed well construction details for OWDFMW01R are shown on Figure 3. The bentonite grout slurry (or chips, where required) will be slowly emplaced via tremie pipe to ensure proper filling of the annulus and to avoid bridging. Dry bentonite chips, where used, will be tremied and hydrated with clean, potable water using at least 5 gallons of water per 50-pound bag of chips. The remaining annular space from approximately 7 to 2 ft bgs will be finished by grouting with cement bentonite grout. Well construction diagrams will be provided on the geologic logs.

Because the rock formation is not pressured, blowouts are not anticipated to occur. However, as described above, voids are anticipated to be encountered and need to be taken into consideration during well installation. In the event that voids or blowouts are encountered, bentonite chips will be emplaced down hole to close out or plug the void.

3.3.2.3 OWDFMW01R Monitoring Well Surface Completion

The monitoring well will be completed in accordance with Procedure I-C-1, *Monitoring Well Installation and Abandonment* (DON 2015). Monitoring well OWDFMW01R will be completed above ground with an 8-inch-diameter steel protective casing fitted with a locking, tamper-proof lid that covers the protective casing and well head. The lock will be recessed and covered for added protection, and permanent labels will be applied both inside and outside of the casing via painting, marking, or engraving on the protective casing or surface completion. The steel casing will be set in concrete at the well head for strength, security, and to provide a surface seal. A 3.5-ft by 3.5-ft square concrete pad, 2 ft thick, will be installed around the protective steel casing. The minimum stickup height of the steel casing will be 3 ft. Approximately 1 ft of the concrete pad will extend above the ground surface. The protective steel casing will extend above the well casings so that there is approximately 6 inches of clearance between the well head and locking lid. Coarse sand will be poured into the space between the well and protective casing to a level of approximately 6 inches below the well head. Four steel bollards will be placed slightly beyond each corner of the concrete pads. The bollards will extend approximately 2 ft bgs and approximately 3 ft above ground surface, and each will be individually set in concrete. The bollards and protective steel casing will be painted bright yellow for high visibility.

3.3.3 Rock Coring

In bedrock, subsurface material will be continuously sampled using wet rotary wireline coring to record the lithologic characteristics and sample description of the subsurface material during the drilling of the wells in accordance with Procedure I-B-1, *Soil Sampling* (DON 2015). Continuous rock cores will be collected as the monitoring well boreholes are advanced through the basaltic bedrock. Rock coring will commence when the borings reach competent bedrock, which is anticipated to occur just beneath the lower-tunnel access concrete floor at RHMW01R and at approximately 50 ft bgs at OWDFMW01R. All drilling in rock will be accomplished by diamond core drilling methods in general accordance with ASTM D2113 (ASTM 2014).

The drill rig will be equipped with 5-ft-long, 3.78-inch outer diameter (OD) core barrels (yielding a 2.5-inch-diameter rock core [HQ bit size]), and the cores will be recovered with a wireline and quad-latch retrieval system. A 4.83-inch-OD core barrel (yielding a 3.35-inch-diameter rock core [PQ bit size]) may also be used, depending on site conditions. Borings may intersect fault zones where poor rock or difficult drilling conditions may be encountered. All reasonable measures to maximize core recovery will be taken, including timely replacement of worn equipment such as drill bits or core sleeves before wear-induced loss of recovery occurs, and changes in type of drill bit, rate of feed, down-pressure on the drill bit, volume of cooling water, length of coring interval, or type of coring equipment. Grinding of the core after a core barrel has become blocked will not be permitted.

A blocked core barrel will be pulled regardless of the interval drilled. Clean water will be brought in from an offsite potable water source for use as circulation fluid during rock coring and drilling.

Checks will be made to identify the presence of perched groundwater or contaminated unconsolidated material while drilling as described in the introductory portion of Section 3.3. If perched groundwater conditions or zones of contamination are identified, then permanent conductor casing will be installed as described in Section 3.3.4. If additional intervals of unconsolidated material or groundwater contamination are observed after permanent conductor casing has been installed, then the borehole will be abandoned as described in the MWIWP (as noted in Section 3.3.5 of this Addendum), and a new boring will be advanced with permanent conductor casing set below the depth of the deepest contamination encountered and in a low-permeability zone (e.g., clay, silt, or low-porosity basalt layer) based on visual observation of unconsolidated material samples or rock core.

The cores will be inspected and logged to characterize the lithology and evaluate potential pathways for migration of NAPL and associated constituents. A summary rock core chart will be used in the field to log the information. In general, each log will note rock-quality designation; rock color; texture; strength; degree and orientation of fracturing; shape, size and volume of voids; weathering; and secondary staining or mineralization. Additionally, details of basalt flow and intraflow structures (e.g., a'ā clinker flow-top breccias [clinker sub-types], accretionary lava clasts, simple vesicular flow tops, vesicular flow lobes, inflated pāhoehoe lobes, spatter deposits, lava tubes, a'ā columnar dense core interiors, a'ā clinker flow-bottom breccias, normal flow bottoms, and flow levees) will be included in logging of the core. Fracture types (i.e., the difference between tectonic fractures, primary cooling joints, and drilling-induced fractures) will also be noted. High-resolution photographs will be taken to photodocument the cores, and detailed photo logs will be prepared. The Geological Society of America rock color chart with Munsell color chips will be used for color characterization (Munsell 2009). Lithologic descriptions, photoionization detector screening results, and other observations will be recorded on the geologic logs in conformance with Procedure I-E, *Soil and Rock Classification* (DON 2015). Discrete subsurface unconsolidated material sampling is described in Section 3.3.9.

Cores will be stored in a secure on-island location so that they are available for inspection until the work conducted under AOC Sections 6 and 7 is complete. Storage required beyond the completion of AOC Sections 6 and 7 will be evaluated by the Navy.

3.3.4 Conductor Casing

To minimize the potential for perched water or contaminated media to migrate downward and impact the basal aquifer, which is a drinking water source, conductor casing will be installed if zones of perched water or contamination are identified. The purpose of the conductor casing is to isolate zones of perched water or contaminated media to prevent cross contamination between the perched groundwater/contaminated media and the basal aquifer. The conductor casing will be centered within the borehole using stainless steel centralizers spaced at approximately 40-ft intervals. The centralizers will be aligned so that they do not interfere with the insertion and removal of the tremie pipe, if necessary. The annular space to be grouted will be a minimum of 1.5 inches beyond the casing. The conductor casing will be pressure-grouted in place as soon as possible after installation using a packer assembly and tremie pipe installed inside of the conductor casing that will allow the grout to be pumped through the packer assembly until it rises to the ground surface around the casing, or with tremie placed in the annular space around the casing. The annulus will be sounded to check for settling of the grout within 24 hours of placement. Following the grouting procedure, the

grout will be left undisturbed for a minimum of 24 hours for curing. Drilling activities will then be resumed until the target depth is reached.

If permanent casing is installed and a second layer with evidence of contamination (i.e., visual, olfactory, sustained PID readings above ambient background conditions, or staining on drill cuttings and recovered rock cores) is encountered, the boring will be abandoned by grouting as described in the MWIWP (as noted in Section 3.3.5 of this Addendum). A new boring will then be advanced so that multiple contaminated zones can be cased off. At OWDFMW01R, a larger-diameter boring could be advanced that can accommodate the installation of multiple casings with a minimum 2-inch annular space.

3.3.5 Borehole Abandonment

Borehole abandonment procedures are presented in the MWIWP (DON 2016b).

3.3.6 Monitoring Well Development

Monitoring well development procedures are presented in the MWIWP (DON 2016b).

3.3.7 Dedicated Groundwater Pump System Installation

Groundwater pump system installation procedures are presented in the MWIWP (DON 2016b).

3.3.8 Potable Water Sampling

Potable water sampling procedures are presented in the MWIWP (DON 2016b).

3.3.9 Subsurface Unconsolidated Material Sampling

The samples of subsurface unconsolidated material (i.e., soil or any material of small grain size, including coarse-grained sand or smaller grain size, such as clay, sands, and clinker zone sand) will be inspected for evidence of contamination (visual, olfactory, or elevated PID readings) in order to evaluate the potential migration of NAPL and associated constituents. The collection of subsurface material for laboratory analysis will be conducted in accordance with Procedure I-B-1 *Soil Sampling,* and samples will be handled in accordance with Procedure III-F, *Sample Handling, Storage, and Shipping* (DON 2015). If unconsolidated material is present at depths lower than the elevation of the tank bottoms, or if contaminated unconsolidated material is encountered at any depth in the subsurface, discrete samples will be collected for laboratory analysis of COPCs to provide additional data on the level of contamination present in the area. Should unconsolidated material be sampled, field quality control (QC) samples will also be collected in accordance with Table 3-2.

Table 3-2: Field Quality Control Samples

QC Sample	Analytical Group [a]	Frequency [b]	DQI	Measurement Performance Criteria
Field duplicate	All	10% of primary samples collected per matrix per analytical method	Precision	RPD ≤100% unconsolidated material (judgmental) [c]
Field blank	All	Once per source of decontamination water per sampling event	Adequacy of the decontamination water quality	≤1/2 of LOQ
Equipment rinsate	All	5% of primary samples collected per matrix per analytical method	Adequacy of the decontamination process	≤1/2 of LOQ

QC Sample	Analytical Group [a]	Frequency [b]	DQI	Measurement Performance Criteria
Trip blank	VOCs, TPH-g (soil/unconsolidated material)	One per cooler	Contamination during sample transport	≤2 of LOQ

% percent
DQI data quality indicator
LOQ limit of quantitation
RPD relative percent difference
TPH-g total petroleum hydrocarbons – gasoline range organics
VOC volatile organic compound
[a] Refer to Section 5.2 of the MWIWP for a list of all analytical groups.
[b] Per *Project Procedures Manual,* Procedure III-B, *Field QC Samples* (DON 2015).
[c] Per *Project Procedures Manual,* Procedure II-A, *Data Validation* (DON 2015).

Unconsolidated material will be collected from split-spoon samplers prior to encountering solid basalt or from core barrels thereafter. Using the discrete sampling approach, approximately 100 grams of unconsolidated material for non-volatile-organic-compound (VOC) analyses will be collected using disposable scoops or spoons and placed in appropriate containers for each subsurface unconsolidated material sample as specified in Section 4. Material collected for VOC analysis will be collected using 5-gram plugs using EnCore, Terra Core, or equivalent samplers. To minimize VOC loss during the sampling effort, the VOC sample plugs will be collected as quickly as possible and placed in laboratory-supplied water- and methanol-preserved containers.

All sample containers will be labeled with the sampling location, date and time of collection, and unique sample identifier as discussed in Section 4.1, and recorded in the field logbook. Sample containers will be placed in re-sealable plastic zip bags, kept in coolers containing wet ice, and preserved in accordance with analytical method requirements and as specified in Section 4. Samples will be shipped to the analytical laboratory via overnight airfreight.

3.4 SURVEYING

Groundwater flow conditions have been evaluated within and around the Facility; however, there remains uncertainty in the magnitude and directions of hydraulic gradients. The uncertainties primarily result from inconsistencies and potential errors with survey data and the potential for measurement error if the monitoring wells are not truly vertical. All wells in the groundwater monitoring network will be resurveyed and their vertical alignment will be checked to see if corrections need to be made to account for any significant deviation.

Accurate surveyed top-of-casing (TOC) elevations tied into the same datum as surrounding wells will be necessary to establish accurate groundwater elevations and estimate groundwater flow directions. A first order survey will be conducted to determine northing and easting coordinates referenced to the Hawai'i State Plane Zone 3, North American Datum (NAD) 83 (ft) coordinate system, and ground surface and TOC elevations referenced in ft msl. The survey will be conducted in coordination with the National Oceanic and Atmospheric Administration's National Geodetic Survey to develop a plan that meets the accuracy requirements for this project. Detailed survey methodology and procedures will be presented in the forthcoming project SAP (see DON 2016c).

3.5 EQUIPMENT DECONTAMINATION AND OTHER QUALITY CONTROL PROCEDURES

Equipment will be decontaminated in accordance with Procedure I-F, *Equipment Decontamination* (DON 2015).

3.6 INVESTIGATION-DERIVED WASTE MANAGEMENT AND DISPOSAL

Unconsolidated material and liquid investigation-derived waste (IDW) generated during monitoring well installation and development activities will be collected at the end of each day. The IDW will be evaluated based on the corresponding unconsolidated material and groundwater sampling data and IDW samples (including liquid wastes generated during drilling operations, well development water, and decontamination liquids) to select appropriate disposal methods. IDW will be stored in U.S. Department of Transportation-approved 55-gallon steel drums, placed on pallets, covered with tarps, and temporarily stored at a secure, Navy-designated staging area. As an alternative and to facilitate drilling activities, drill cuttings may be placed in rolloff containers. Rolloff containers will be covered with a tarp to prevent them from filling up with precipitation.

The IDW will be handled, stored, and labeled in accordance with Procedure I-A-6, *Investigation-Derived Waste Management* (DON 2015). The drums will be segregated according to source and matrix, and at least one representative composite IDW sample will be collected from each grouping for waste characterization in accordance with Procedure I-D-1, *Drum Sampling* (DON 2015). IDW characterization samples will be submitted to a Department of Defense (DoD) Environmental Laboratory Accreditation Program (ELAP)-certified laboratory for analysis. Waste profile forms will be prepared and submitted to potential disposal facilities for approval. The IDW will be kept at the staging area until the IDW analytical data are received and associated waste profile forms are approved by the disposal facilities. The IDW will then be removed from the staging area, transported, and disposed of at the approved disposal facilities. IDW will be disposed of within 90 calendar days of the generation date. Disposable personal protective equipment and disposable sampling equipment will be collected in plastic trash bags and disposed of as municipal solid waste.

4. Sample Details

Subsurface unconsolidated material, geotechnical, and potable water sample details are presented in Table 4-1, Table 4-2, and Table 4-3, respectively.

4.1 SAMPLE CUSTODY REQUIREMENTS

Each sample will be assigned a chain of custody (CoC) sample identification (ID) number and a descriptive ID number in accordance with NAVFAC Pacific Environmental Restoration Program Procedure I-A-8, *Sample Naming* (DON 2015). All sample ID numbers will be recorded in the field logbook in accordance with Procedure III-D, *Logbooks* (DON 2015). The CoC sample ID number (the only ID number submitted to the analytical laboratory) is used to facilitate data tracking and storage. The CoC sample ID number allows all samples to be submitted to the laboratory without providing information on the sample type or source. The descriptive ID number is linked to the CoC sample ID number, which provides information regarding sample type, origin, and source.

Table 4-1: Subsurface Unconsolidated Material Sample Details

				Analysis Group:	TPH-d/TPH-o	TPH-g	VOCs	PAHs
				Analytical Method:	SW-846 8015	SW-846 8015	SW-846 8260	SW-846 8270
				Container Type:	8-oz clear or amber borosilicate wide-mouth jar, with Teflon-lined lid	Pre-weighed 40-mL clear or amber borosilicate VOA vial, with Teflon septum-lined cap	Pre-weighed 40-mL clear or amber borosilicate VOA vial, with Teflon septum-lined cap	8-oz clear or amber borosilicate wide-mouth jar, with Teflon-lined lid
				Preservative:	≤6 °C	1 × 5mL methanol-preserved; ≤6 °C	2 × 10mL water-preserved; 1 × 5mL methanol-preserved; ≤6 C°	≤6 C°
Analytical laboratory: APPL, Inc.				Holding Time (Preparation/Analysis):	14 days	14 days	7 days (water); 14 days (methanol)	14 days
Site	Matrix	Sampling Point	Sample ID	Depth/Sampling Interval				
Red Hill	Unconsolidated Material [a,b]	RHMW01R	RHMW01R-BS01-S01-Dff.f	TBD	✓	✓	✓	✓
Red Hill	Unconsolidated Material [a,b]	OWDFMW01R	OWDFMW01R-BS01-S01-Dff.f	TBD	✓	✓	✓	✓
Field QC Samples								
Red Hill	Field Duplicate	TBD	Aaaaaa-BScc-Dee-Dff.f	TBD	✓	✓	✓	✓
Red Hill	Matrix Spike/Matrix Spike Duplicate	TBD	Aaaaaa-BScc-See-Dff.f	TBD	✓	✓	✓	✓
Red Hill	Equipment Blank	TBD	Aaaaaa-WQ-Eee-ffff	—	✓	✓	✓	✓
Red Hill	Trip Blank	TBD	Aaaaaa-WQ-Tee-ffff	—	—	✓	✓	—
Red Hill	Field Blank	TBD	Aaaaaa-WQ-Fee-ffff	—	✓	✓	✓	✓
Miscellaneous Samples								
Red Hill	IDW	RHMW01R	RHMW01R-IDW-01-ffff	—	—	—	✓	—
Red Hill	IDW	OWDFMW01R	OWDFMW01R-IDW-01-ffff	—	—	—	✓	—

✓	analysis is applicable to sample	ffff	sample collection date (e.g., "0215" for February 15)
—	analysis is not applicable to sample	mL	milliliter
°C	degree Celsius	oz	ounce
Aaaaaa	sampling point	PAH	polynuclear aromatic hydrocarbon
APPL	Agriculture & Priority Pollutants Laboratories, Inc.	TBD	to be determined
	908 N Temperance Ave., Clovis, CA 93611	TPH-d	total petroleum hydrocarbons – diesel range organics
cc	consecutive sampling location number	TPH-g	total petroleum hydrocarbons – gasoline range organics
ee	chronological sample number from a particular sampling location	TPH-o	total petroleum hydrocarbons – residual range organics (i.e., TPH-oil)
ff.f	depth of sample in feet (ft) bgs (measured to the tenth of a foot)	VOA	volatile organic analyte

[a] Unconsolidated material includes soil, coarse-grained sand, and smaller grain size material, such as clay, sands, and clinker zone sand.
[b] Unconsolidated material will be sampled as described in Section 3.3.9.

Table 4-2: Geotechnical Sample Details

Analytical laboratory: APPL, Inc.				Analysis Group:	Atterberg Limits	Effective Porosity [a]	Permeability	Grain Size Distribution
				Analytical Method: [b]	ASTM D4318	ASTM D6836M	ASTM D5084	ASTM D422
				Container Type:	Core	Core	Core	Core
				Preservative:	N/A	N/A	N/A	N/A
				Holding Time (Preparation/Analysis):	N/A	N/A	N/A	N/A
Site	Matrix	Sampling Point	Sample ID	Depth/Sampling Interval				
Red Hill	Unconsolidated material [c,d]	RHMW01R	RHMW01R-BS01-S01-Dff.f	TBD	✓	✓	✓	✓
Red Hill	Unconsolidated material [c,d]	OWDFMW01R	OWDFMW01R-BS01-S01-Dff.f	TBD	✓	✓	✓	✓

(cont'd)				Analysis Group:	Cation Exchange Capacity	pH	Total Organic Carbon
				Analytical Method: [b]	EPA 9081	ASTM G51	Walkley Black
				Container Type:	Core	Core	Core
				Preservative:	N/A	N/A	N/A
				Holding Time (Preparation/Analysis):	N/A	N/A	N/A
Site	Matrix	Sampling Point	Sample ID	Depth/Sampling Interval			
Red Hill	Unconsolidated material [c,d]	RHMW01R	RHMW01R-BS01-S01-Dff.f	TBD	✓	✓	✓
Red Hill	Unconsolidated material [c,d]	OWDFMW01R	OWDFMW01R-BS01-S01-Dff.f	TBD	✓	✓	✓

✓ analysis is applicable to sample
ff.f depth of sample in feet (ft) bgs (measured to the tenth of a foot)
N/A not applicable
TBD to be determined
[a] Effective porosity includes total porosity, moisture content, density, and specific gravity.
[b] Sources: (ASTM 2007, 2010, 2012, 2016a,b)
[c] Unconsolidated material includes soil, coarse-grained sand, and smaller grain size material, such as clay, sands, and clinker zone sand.
[d] Unconsolidated material will be sampled as described in Section 3.3.9.

Table 4-3: Potable Water Sample Details

				Analysis Group:	TPH-d/TPH-o	TPH-g	VOCs	PAHs
				Analytical Method:	SW-846 8015	SW-846 8015	SW-846 8260	SW-846 8270
				Container Type:	1-L amber borosilicate wide- or narrow-mouth bottle, with Teflon-lined lid	3 × 40-mL clear or amber borosilicate VOA vial, with Teflon septum-lined cap	3 × 40-mL clear or amber borosilicate VOA vial, with Teflon septum-lined cap	1-L amber borosilicate wide- or narrow-mouth bottle, with Teflon-lined lid
				Preservative:	≤6 °C	HCl-preserved; ≤6 C°	HCl-preserved; ≤6 C°	≤6 C°
Analytical laboratory: APPL, Inc.				Holding Time (Preparation/Analysis):	7 days	14 days	14 days	7 days
Site	Matrix	Sampling Point	Sample ID	Depth/Sampling Interval				
Red Hill	Water	Potable Water [a]	Aaaaaa-PW01-S01-ffff	TBD	✓	✓	✓	✓
Total Number of Samples to the Laboratory					1			

✓ analysis is applicable to sample
Aaaaaa sampling point
ffff sample collection date (e.g., "0215" for February 15)
HCl hydrochloric acid
L liter
TBD to be determined
[a] Potable water will be sampled prior to potable water use during drilling activities (see Section 3.3.8).

4.1.1 CoC Sample Identification Number

A CoC sample ID number will be assigned to each sample as follows, to facilitate data tracking and storage:

ERHxxx

Where:

ERH = Designates the samples for the Red Hill Bulk Fuel Storage Facility Groundwater Long-Term Monitoring program

xxx = Chronological number, starting with next consecutive number (will be determined prior to field work and is dependent on the last number used in the most recent groundwater monitoring event)

QC samples will be included in the chronological sequence.

4.1.2 Descriptive Identification Number

A descriptive ID number (for internal use only) will identify the sampling location, type, sequence, matrix, and depth. The descriptive ID number is used to provide sample-specific information (e.g., location, sequence, and matrix). The descriptive identifier is not revealed to the analytical laboratory. The descriptive ID number for all samples is assigned as follows:

Aaaaaa-bbcc-dee-Dff.f

Where:

Aaaaaa = Site area (see Table 4-4)

bb = Sample type and matrix (see Table 4-5)

cc = Location number (e.g., borehole 01, 02, 03)

d = Field QC sample type (see Table 4-6)

ee = Chronological sample number from a particular sampling location (e.g., 01, 02)

D = The letter "D" denoting depth

ff.f = Depth of sample in feet (ft) bgs (measured to the tenth of a foot). For field blanks, trip blanks and equipment blanks, the depth field will contain the month and date of collection.

Table 4-4: Area Identifiers

Identifier	Site Area
RHMW01R	Monitoring Well RHMW01R
OWDFMW01R	Monitoring Well OWDFMW01R

Table 4-5: Sample Type and Matrix Identifiers

Identifier	Sample Type	Matrix
BS	Subsurface Unconsolidated Material	Solid
WQ	Water Blanks	Water
PW	Potable Water	Water

Table 4-6: Field QC Sample Type Identifiers

Identifier	Field or QC Sample Type	Description
S	Primary Sample	All field samples, except QC samples
D	Duplicate	Co-located for unconsolidated material
E	Equipment Blank	Water
B	Field Blank	Water
T	Trip Blank	Water

For example, the sample number OWDFMW01R-BS01-S01-D20.0 would indicate that the sample is the first sample collected from the first subsurface unconsolidated material location, encountered at 20 ft bgs, from the borehole advanced for monitoring well OWDFMW01R. The duplicate sample would be designated as OWDFMW01R-BS01-D01-D20.0. These characters will establish a unique descriptive identifier that will be used during data evaluation.

5. References

ASTM International (ASTM). 2007. *Standard Test Method for Particle-Size Analysis of Soils*. D422-63(2007)e2. West Conshohocken, PA.

———. 2010. *Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils*. D4318-10e1. West Conshohocken, PA.

———. 2012. *Standard Test Method for Measuring pH of Soil for Use in Corrosion Testing*. G51 - 95(2012). West Conshohocken, PA.

———. 2014. *Standard Practice for Rock Core Drilling and Sampling of Rock for Site Exploration*. D2113-14. West Conshohocken, PA.

———. 2016a. *Standard Test Methods for Determination of the Soil Water Characteristic Curve for Desorption Using a Hanging Column, Pressure Extractor, Chilled Mirror Hygrometer, or Centrifuge*. D6836-16. West Conshohocken, PA.

———. 2016b. *Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter*. D5084-16a. West Conshohocken, PA.

Department of Health, State of Hawaii (DOH). 2016. *Technical Guidance Manual for the Implementation of the Hawaii State Contingency Plan*. Interim Final. Honolulu, HI: Hazard Evaluation and Emergency Response Office. August.

Department of the Navy (DON). 2000. *Phase II Remedial Investigation, Red Hill Oily Waste Disposal Facility, Halawa, Oahu, Hawaii*. Prepared by Earth Tech, Inc., Honolulu, HI. Pearl Harbor, HI: Pacific Division, Naval Facilities Engineering Command. September.

———. 2002. *Red Hill Bulk Fuel Storage Facility Investigation Report (Final) for Fleet Industrial Supply Center (FISC), Oahu, Hawaii*. Prepared by AMEC Earth & Environmental, Inc., Huntsville, AL. Pearl Harbor, HI: Pacific Division, Naval Facilities Engineering Command. August.

———. 2007. *Red Hill Bulk Fuel Storage Facility Final Technical Report, Pearl Harbor, Hawaii.* Prepared by TEC Inc., Honolulu, HI. Pearl Harbor, HI: Naval Facilities Engineering Command, Pacific. August.

———. 2015. *Final Project Procedures Manual, U.S. Navy Environmental Restoration Program, NAVFAC Pacific.* JBPHH HI: Naval Facilities Engineering Command, Pacific. May.

———. 2016a. *Health and Safety Plan, Investigation at Red Hill Bulk Fuel Storage Facility, Joint Base Pearl Harbor-Hickam, O'ahu, Hawai'i; June 22, 2016.* Prepared by AECOM Technical Services, Inc., Honolulu, HI. Prepared for Defense Logistics Agency Energy, Fort Belvoir, VA, under Naval Facilities Engineering Command, Hawaii, JBPHH HI. June 22.

———. 2016b. *Monitoring Well Installation Work Plan, Red Hill Bulk Fuel Storage Facility, Joint Base Pearl Harbor-Hickam, Oahu, Hawaii; August 29, 2016.* Prepared by AECOM Technical Services, Inc., Honolulu, HI. Prepared for Defense Logistics Agency Energy, Fort Belvoir, VA, under Naval Facilities Engineering Command, Hawaii, JBPHH HI. August 29.

———. 2016c. *Work Plan/Scope of Work, Investigation and Remediation of Releases and Groundwater Protection and Evaluation, Red Hill Bulk Fuel Storage Facility, Joint November 5, 2016, Revision 01.* Prepared by AECOM Technical Services, Inc., Honolulu, HI. Prepared for Defense Logistics Agency Energy, Fort Belvoir, VA, under Naval Facilities Engineering Command, Hawaii, JBPHH HI. November 5.

Environmental Protection Agency, United States, Region 9; and State of Hawaii Department of Health (EPA Region 9 and DOH). 2015. *Administrative Order on Consent In the Matter of Red Hill Bulk Fuel Storage Facility, EPA Docket No: RCRA 7003-R9-2015-01; DOH Docket No: 15-UST-EA-01.* September.

Munsell Color Company (Munsell). 2009. *Geological Rock-Color Chart with Genuine Munsell® Color Chips. Revision of Geological Society of America (GSA) Rock-Color Chart.* Produced in cooperation with GSA. Baltimore, MD.

This page intentionally left blank

Appendix A:
RHMW01 and OWDFMW01
Boring and Monitoring Well Construction Logs
(DON 2000, 2002)

This page intentionally left blank

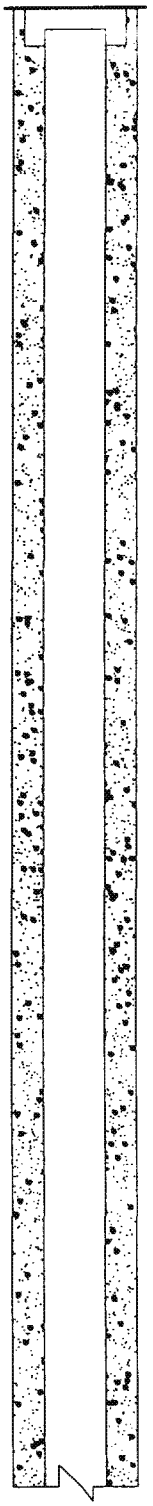
PROJECT: Red Hill Bulk Storage Facility
CLIENT: PACNAVFACENGCOM

Boring/Monitoring Well No. B-V1D
Project No. CTO 0229

LOCATION: V1D - Basal Aquifer	ELEVATION: 102.56		
DRILLER: Salisbury & Associates, Inc.	DATE DRILLED: 2/13/01	LOGGED BY: Lance Williams	
DRILL RIG: SAITECH EH5, Portable Core Drill	DEPTH TO WATER>	FIRST: 86.0	COMPL.: 86.1
BORING ANGLE: 90	WELL DIAMETER (inch): 1"		

Corrected Elevation/ Boring Length (ft)	Core Run Number	PID Reading (ppm)	Sample Number	Core Recovery %	SOIL DESCRIPTION
102.56 (0)	1	NM		100	Concrete 0-2' over fine to coarse sand with fine gravel
102.06	2	172		83	and silt 2-2.5; basalt 2.5'; no odor
98.56		NM			Small to large vesicles; no odor; 10YR 3/1
	3	NM		71	Small to medium vesicles; no odor; 10YR 3/1 to 2/1
		99.2			
95.36					
94.16	4	NM		0	Small vesicles; no odor; 5YR 3/2 to 10YR 2/2
93.66	5	NM		33	
91.76 (10)	6			100	Small to medium vesicles; no odor; 5YR 3/2 to 10YR 2/2
	7	124		105	
	8			93	Small to large vesicles; no odor; 10YR 2/2
					Small to large vesicles; no odor; 10YR 2/2 to 3/2
86.06	9	NM		96	Primarily small to medium vesicles; no odor; 10YR 2/2
81.66 (20)	10	NM		100	Small to primarily large vesicles; no odor; 10YR 2/2 to 5YR 3/2 to 10YR 3/1
76.26	11	3.2		100	Small to large vesicles; no odor; 10YR 3/1 to 5YR 3/2
71.26 (30)	12	10.8		100	Small to medium vesicles; no odor; 5YR 3/2 to 10YR 3/1
66.16	13	NM		102	Small to large vesicles; no odor; 5YR 3/2 to 10YR 3/1
60.96 (40)	14	NM		100	Small to large vesicles; no odor; 10YR 2/2 to 5YR 3/2
57.26					
56.91	15	NM		98	Small to medium vesicles; no odor; 10YR 2/2 to 5YR 3/2
53.06 (50)	16	NM		98	Void
					Small to medium vesicles; no odor; 10YR 2/2 to 5YR 3/2
48.06	17	1.0		89	Small to medium vesicles; no odor; 10YR 2/2 to 5YR 3/2
43.36 (60)	18	6.9		100	Small to large vesicles; no odor; 10YR 3/1 to 2/2 to 5YR 3/2
38.36	19	1.8		83	Small to large vesicles; no odor; 10YR 2/5 to 5YR 3/2
34.26 (70)	20	0.0		92	Small to medium vesicles; no odor; 10YR 2/1 to 2/2 tp 5YR 3/2
29.16	21	0.0	RH-BR-V1D-S01	102	Small vesicles; no odor; 10YR 2/1

WELL CONSTRUCTION



This information pertains only to this boring and should not be interpreted as being indicitive of the site.

Corrected elevations are provided for angle borings.

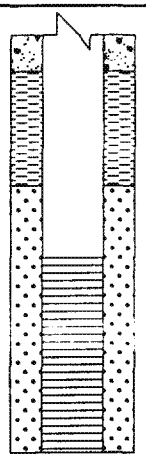
PROJECT: Red Hill Bulk Storage Facility
CLIENT: PACNAVFACENGCOM

Boring/Monitoring Well No. B-V1D
Project No. CTO 0229

LOCATION: V1D - Basal Aquifer	ELEVATION: 102.56		
DRILLER: Salisbury & Associates, Inc.	DATE DRILLED: 2/13/01	LOGGED BY: Lance Williams	
DRILL RIG: SAITECH EH5, Portable Core Drill	DEPTH TO WATER>	FIRST: 86.0	COMPL.: 86.1
BORING ANGLE: 90	WELL DIAMETER (inch): 1"		

Corrected Elevation/ Boring Length (ft)	Core Run Number	PID Reading (ppm)	Sample Number	Core Recovery %	Graphic Log	SOIL DESCRIPTION	WELL CONSTRUCTION
24.06	22	0		100		Medium vesicles; no odor; 10YR 2/2	
18.86	23	0.0	RH-BR-V1D-S02	106		Medium vesicles; no odor; 10YR 2/2	
15.66	24	0.0		96		Large vesicles; no odor; 10YR 2/1	
10.16							
9.56	25	0.0		86		Small vesicles; no odor; 10YR 2/2	
6.56						Clinker zone 93-100'	
4.96	26	0.0		56		Medium vesicles; clinker zone; no odor; 10YR 2/1	
4.96	27	0.0	RH-BR-V1D-S03	50		Medium vesicles; clinker zone; no odor; 10YR 2/2	
2.56						Clinker zone	
						B-V1D terminated at 100.0'	

80 90 100 110 120 130 140 150



This information pertains only to this boring and should not be interpreted as being indicitive of the site.

Corrected elevations are provided for angle borings.

EARTH TECH

Borehole/Well Construction Log

Project Name: Red Hill Phase II RI/FS	Project Number: CTO-0034	**Borehole Number:** MW08	
Borehole Location: Near AST	*Northing:* 75254.41 *Easting:* 530845.19	Sheet *1* of *9*	
Drilling Agency: Valley Well Drilling	Driller: Dean Mclure, David Brown		
Drilling Equipment: B59, Jaswell 3000	Date & Time Started: 4/7/98	Total Depth (feet): 142.8	
Drilling Method: Air Rotary, Hollow Stem Auger	Top of Casing Elevation (feet msl): 138.06	Date & Time Finished: 4/24/98	Depth to Water (feet): See remarks
Size and Type of Bit: -	Borehole Diameter (in): 10	Sample Type: *Bulk:* NA *Drive:* x *SS:* 16 *Grab:* NA	*Sample Length (ft):* 1.5' or 5' *Driving Weight:* NA *Drop Length:* NA
Drilling Fluid: Air	Drilling Angle: (degrees) 90	Number of Samples: 16	
Completion Information: See remarks		Logged By: W. Wen	Checked By: B. Tsutsui

Depth (feet)	Samples: Number	Type	Blow Count	Percent Recovery	Time	Estimated %: Gravel	Sand	Fines	Log: Graphic	USCS or Rock Type	Lithologic Description	Well Construction Diagram	Remarks
0											Topsoil		Ground surface elevation: 135.67 feet msl
1			50/5"	40	1352	5	TR	95		CL	**LOW PLASTIC INORGANIC CLAY**; black, 5YR 2.5/1; dry; hard; CL; 95% low plastic inorganic clay; 5% fine, subangular gravel; trace amount of sand and roots.		
2													Steel casing (12 inch diameter)
3													PVC Casing
4													Grout
5			50/5"	35	1359	TR	80	20		SC	**CLAYEY SAND**; dark yellowish brown, 10YR 4/6; dry; dense; SC; 80% fine, medium, coarse, subrounded sand; 20% low plastic inorganic clay; trace amount of fine, subangular gravel.		
6													
7													
8													
9													
10			50/6"	15	1410	-	-	-		IE	**EXTRUSIVE**; basalt; gray, 10YR 6/1; vesicular basalt; fresh; hard; dry; IE.		
11													
12													
13													
14													
15													

Red Hill Phase II RI/FS\CTO-0034

EARTH TECH

Borehole/Well Construction Log (Continuation Sheet)

Project Name: Red Hill Phase II RI/FS	Project Number: CTO-0034	Borehole Number: MW08
Borehole Location: Near AST		Sheet 2 of 9

Depth (feet)	Samples: Number	Samples: Type	Samples: Blow Count	Samples: Percent Recovery	Samples: Time	Estimated %: Gravel	Estimated %: Sand	Estimated %: Fines	Log: Graphic	Log: USCS or Rock Type	Lithologic Description	Well Construction Diagram	Remarks
16			NA	5	1420	-	-	-		IE	Same as above		
18			50/3"	0		-	-	-			No Recovery Called off at 1435, 4/7/98		
20			NA	70	1300	-	-	-			No recovery		
22						-	-	-			No Recovery		
24						40	-	60		CL	**GRAVELLY CLAY**; strong brown and dark gray, 7.5YR 5/6, 4/1; dry; soft; CL; 60% high plastic inorganic clay; 40% fine, subrounded basalt gravel.		
25			NA	0	1442	-	-	-			No Recovery Called off at 1442, 4/13/98		
30													Bottom of steel casing
32			NA	80	1430	-	TR	100		CH	**HIGH PLASTIC INORGANIC CLAY**; dark		

Red Hill Phase II RI/FS\CTO-0034

EARTH TECH

Borehole/Well Construction Log (Continuation Sheet)

Project Name: Red Hill Phase II RI/FS	Project Number: CTO-0034	Borehole Number: MW08
Borehole Location: Near AST		Sheet 3 of 9

Depth (feet)	Samples: Number	Samples: Type	Samples: Blow Count	Samples: Percent Recovery	Samples: Time	Estimated %: Gravel	Estimated %: Sand	Estimated %: Fines	Log: Graphic	Log: USCS or Rock Type	Lithologic Description	Well Construction Diagram	Remarks
33											brown, 7.5YR 3/3; moist; soft; CH; 100% high plastic inorganic clay; trace amount of sand.		
34											Logged at 1439, 4/14/98.		
35													
36						30	TR	70		CL	**GRAVELLY CLAY**; very dark gray and brown, 10YR 3/2; moist; stiff; CL; 30% subrounded gravel; 70% low plastic inorganic clay; trace amount of sand; extensive mottling.		
37			NA	60		-	-	-		IE	**EXTRUSIVE**; basalt; light gray, 5YR 7/2; vesicular basalt; highly weathered; friable; dry; IE.		
38						-	-	-		IE	Same as above		
39						100	TR	-		GP	**POORLY GRADED GRAVEL**; pale olive gray, 5YR 6/2; dry; GP; 100% coarse, subrounded gravel; trace amount of coarse sand.		
40						-	-	-		IE	**EXTRUSIVE**; basalt; pale olive, 5YR 7/2; lightly weathered; massive; friable; dry; IE.		
41													
42			NA	70		80	10	10		GC	**CLAYEY GRAVEL**; strong brown, 7.5YR 4/6; moist; GC; 80% fine, medium and coarse subrounded gravel; 10% coarse subrounded sand; 10% high plastic inorganic clay.		
43													
44						100	-	-		GW	**WELL GRADED GRAVEL**; brown, 7.5YR 4/3; moist; GW; 100% medium coarse subrounded gravel.		
45										IE	**EXTRUSIVE**; basalt; brown, 7.5YR 4/3; highly weathered; vesicular basalt; fractured; moist; IE.		
46						90	5	5		GP	**POORLY GRADED GRAVEL**; strong brown, 7.5YR 4/6; moist; GP; 90% fine, medium, coarse subrounded gravel; 5% coarse, subrounded sand; 5% high plastic inorganic clay.		
47			NA	80		-	-	-		IE	**EXTRUSIVE**; basalt; brown, 7.5YR 4/3; highly weathered; vesicular basalt; fractured; moist; IE.		
48						-	-	100		CH	**HIGH PLASTIC INORGANIC CLAY**; brown, 7.5YR 4/2; moist; firm; CH; 100% medium plasticity inorganic clay.		
49						-	-	-		IE	**EXTRUSIVE**; basalt; olive gray, 5YR 5/2; fresh; vesicular; moist; IE.		
50													

EARTH TECH

Borehole/Well Construction Log (Continuation Sheet)

Project Name: Red Hill Phase II RI/FS	Project Number: CTO-0034	Borehole Number: MW08
Borehole Location: Near AST		Sheet 4 of 9

Depth (feet)	Samples: Number	Samples: Type	Samples: Blow Count	Samples: Percent Recovery	Samples: Time	Estimated %: Gravel	Estimated %: Sand	Estimated %: Fines	Log: Graphic	Log: USCS or Rock Type	Lithologic Description	Well Construction Diagram	Remarks
51													
52			NA	100	1700	-	-	-		IE	Same as above		
53													
54						-	-	-		IE	**EXTRUSIVE**; basalt; gray, 10YR 5/1; most massive basalt with some vesicular fabric; fresh; hard; moist; IE.		
55													
56						-	-	-		IE	**EXTRUSIVE**; basalt; olive gray, 5YR 5/2; fresh; vesicular; moist; IE.		
57			NA	80	0917	-	-	-		IE	No Recovery		
58						-	-	-		IE	Grading to faintly weathered; well developed fracture in basalt.		
59													
60											Color changes to brown (7.5YR 4/4); grading to highly weathered and soft.		
61						70	10	20		GC	**CLAYEY GRAVEL**; dark gray, 5YR 4/1; dry; dense; GC; 70% fine, subangular and subrounded gravel; 20% low plastic, inorganic clay; 10% fine, subangular sand.		
62			NA	85	0947	-	-	-		IE	**EXTRUSIVE**; basalt; brown, 7.5YR 4/4; massive basalt; highly weathered; medium hard; moist; IE.		
63										IE	**EXTRUSIVE**; volcanic breccia; gray, 5YR 5/1; 60% basalt clast; 20% matrix; 20% porosity; faintly weathered; hard; dry; IE.		
64													
65													
66													
67			NA	80	1040	-	-	-			No recovery		

Red Hill Phase II RI/FS\CTO-0034

EARTH TECH

Borehole/Well Construction Log (Continuation Sheet)

Project Name: Red Hill Phase II RI/FS	Project Number: CTO-0034	Borehole Number: MW08
Borehole Location: Near AST		Sheet 5 of 9

Depth (feet)	Samples: Number	Samples: Type	Samples: Blow Count	Samples: Percent Recovery	Samples: Time	Estimated %: Gravel	Estimated %: Sand	Estimated %: Fines	Log: Graphic	Log: USCS or Rock Type	Lithologic Description	Well Construction Diagram	Remarks
68						-	-	-		IE	**EXTRUSIVE**; volcanic breccia; gray, 7.5YR 5/1; 40% basalt clast; 40% matrix; 20% porosity; faintly weathered; hard; wet; IE.		
69						-	-	-		IE	**EXTRUSIVE**; basalt; dark gray, 7.5YR 4/1; massive basalt; fresh; hard; wet; IE.		
70													
71													
72			NA	90	1130	-	-	-		IE	Same as above		
73													
74													
75													
76													
77						-	-	-		IE	Same as above		
78											Switch to Jaswell, no sample taken after 77 feet. Lithology was estimated from blown hole.		
79													
80													
81													
82													
83													
84													
85													

EARTH TECH

Borehole/Well Construction Log (Continuation Sheet)

Project Name: Red Hill Phase II RI/FS	Project Number: CTO-0034	Borehole Number: MW08
Borehole Location: Near AST		Sheet 6 of 9

Depth (feet)	Samples: Number	Samples: Type	Samples: Blow Count	Samples: Percent Recovery	Samples: Time	Estimated %: Gravel	Estimated %: Sand	Estimated %: Fines	Log: Graphic	Log: USCS or Rock Type	Lithologic Description	Well Construction Diagram	Remarks
86						-	-	-		IE	Same as above (Basalt)		
87													
88													
89													
90													
91													
92													
93													
94													
95													
96													
97													
98													
99													
100													
101													
102													Top of Bentonite seal

EARTH TECH

Borehole/Well Construction Log
(Continuation Sheet)

Project Name: Red Hill Phase II RI/FS	Project Number: CTO-0034	Borehole Number: MW08
Borehole Location: Near AST		Sheet 7 of 9

Depth (feet)	Samples: Number	Samples: Type	Samples: Blow Count	Samples: Percent Recovery	Samples: Time	Estimated %: Gravel	Estimated %: Sand	Estimated %: Fines	Log: Graphic	Log: USCS or Rock Type	Lithologic Description	Well Construction Diagram	Remarks
103						-	-	-		IE	Same as above (basalt)		
104													
105													
106													
107													
108													
109													
110													
111													
112													
113													
114													
115													
116													
117													
118													
119													
120													

EARTH TECH

Borehole/Well Construction Log
(Continuation Sheet)

Project Name: Red Hill Phase II RI/FS	Project Number: CTO-0034	Borehole Number: MW08
Borehole Location: Near AST		Sheet 8 of 9

Depth (feet)	Samples: Number	Samples: Type	Samples: Blow Count	Samples: Percent Recovery	Samples: Time	Estimated %: Gravel	Estimated %: Sand	Estimated %: Fines	Log: Graphic	Log: USCS or Rock Type	Lithologic Description	Well Construction Diagram	Remarks
121						-	-	-		IE	Same as above (basalt)		
122													Approximate static basal groundwater level (122.2 feet bgs); top of filter pack
123													
124													
125													
126													
127													
128													
129													
130													
131													
132													Top of screen
133													0.02 inch stainless steel screen
134													
135													
136													
137													

EARTH TECH

Borehole/Well Construction Log (Continuation Sheet)

Project Name: Red Hill Phase II RI/FS	Project Number: CTO-0034	Borehole Number: MW08
Borehole Location: Near AST		Sheet 9 of 9

Depth (feet)	Samples: Number	Samples: Type	Samples: Blow Count	Samples: Percent Recovery	Samples: Time	Estimated %: Gravel	Estimated %: Sand	Estimated %: Fines	Log: Graphic	Log: USCS or Rock Type	Lithologic Description	Well Construction Diagram	Remarks
138						-	-	-		IE	Same as above (basalt)		First encountered depth of basal groundwater (138.5 feet bgs)
139													
140													
141													
142													Bottom of well
											Boring finished at 143 feet on 4/24/98.		Total depth of borehole

Red Hill Phase II RI/FS\CTO-0034

WELL COMPLETION RECORD

JOB NO.: CTO 0034 WELL NO. MW-08 HYDROGEOLOGIST: Bruce Tsutsui

CLIENT: PACNAVFACENGCOM DRILLER: Valley Well Drilling

WELL LOCATION: Near AST DATE/TIME: 4/24/98 10:50

DETAILS OF CONSTRUCTION

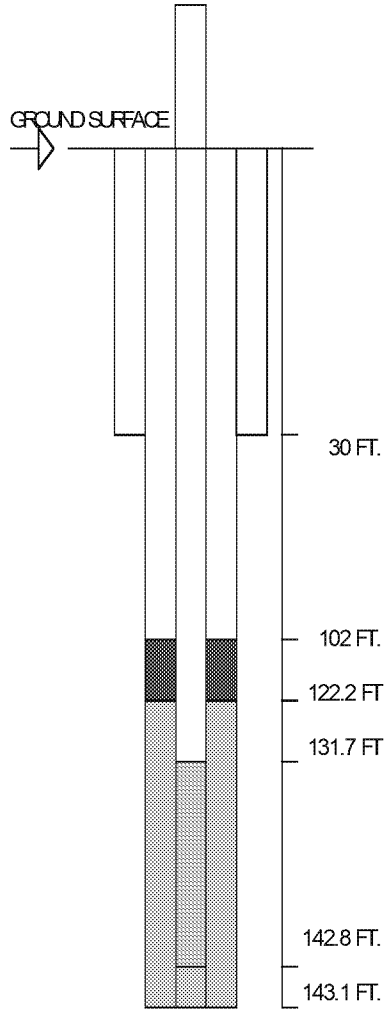
Date Completed	4/24/98
Borehole Diameter (in.)	10
Type and Size of Casing (in.)	PVC; 4
Type and Size of Screen (in.)	Stainless Steel; 4
Screen Perforation Diameter (in.)	0.02
Screen Length (ft.)	11.1
Centralizer Depths (ft.)	N/A

Completion Technique

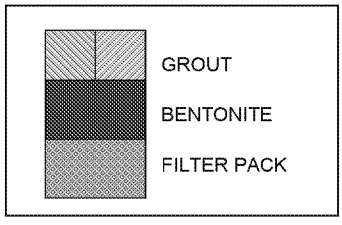
1. Type of Filter Pack and Placement Method
   Lonestar #3
2. Type of Bentonite and Placement Method
   Pellets, chips
3. Type of Grout Mixture and Placement Method
   Portland; tremmie pipe

Description of Potential Problems With Well:
Perched Water

Development Technique
Surge with block during construction; surge with bailer during development



NOTE: ALL DEPTHS ARE REFERENCED TO GROUND SURFACE



Well Head Elevation	138.06 ft (MSL)
Ground Surface Elev.	135.67 ft (MSL)
Well Head Completion Method	Manual crash hole
Drilling Method/Rig Type	B-59; Jaswell

Surface Casing: Type PVC; Diameter 4 in.; Length 2.39 ft.

MATERIALS

Cement (bags)	NA
Filter Pack Material (sand bags)	10
Casing Material (ft.)	131.66
Bentonite (buckets/bags)	1 (pellets) 7 (chips)

Top of Bentonite Seal	102	ft.
Top of Filter Pack	122.2	ft.
Top of Screen	131.66	ft.
Bottom of Screen	142.76	ft.
Bottom of Hole	143.1	ft.

EARTH TECH